LAC STE. ANNE

Alberta
ENVIRONMENT

89-06097/

Lakes attract people. And people want to know why "their" lake is the way it is — why is it so green in July? Is the water quality really deteriorating? How do our activities affect the lake?

This brochure, one of a series on Alberta's lakes, attempts to answer these questions by presenting findings of water quality studies conducted by the Environmental Assessment Division of Alberta Environment.

As you read through the brochure, you may find that you have questions about the concepts and illustrations. At the end is a section called **Explanation of Lake Characteristics**. Refer to this for further interpretation.

Brochures are available for the following lakes:

Sandy Lake	Pine Lake	Lac la Biche
Lac la Nonne	Garner Lake	Nakamun Lake
Wizard Lake	Skeleton lake	Lac Ste. Anne
Pigeon Lake		

March 1989

Lac Ste. Anne is located about 60 km west of Edmonton. If you are driving from the city, take Highway 16, then turn north on Highway 43 and west on Secondary Road 633 to Alberta Beach.

The lake was named for Saint Anne, mother of the blessed Virgin Mary, by Father Thibault who founded the Lac Ste. Anne Mission on the south shore in 1843.[1] Lac Ste. Anne has been an important spiritual place to native people for many years and is believed to have healing properties. People from as far away as the United States have made a pilgrimage there since the 1800s. Lac Ste. Anne has abundant fish. For many years it was the main source of fish for Fort Edmonton.

Lac Ste. Anne is extremely popular with Edmonton area residents. Cottage development in the Village of Alberta Beach began in the early 1900s. At present, there are seven summer villages, a number of subdivisions, a hamlet and an Indian reserve located on the lakeshore. Public access is available at several areas around the lake. A government pier is located at Alberta Beach.

Fishing

Sport fishing for walleye and northern pike is an important recreational activity on Lac Ste. Anne, and the lake supports commercial and domestic fisheries. The lake also contains lake whitefish, yellow perch, white suckers, burbot, spottail shiners and brook stickleback. Lake whitefish, walleye and yellow perch are considerably more abundant in the east basin than in the west.[2].

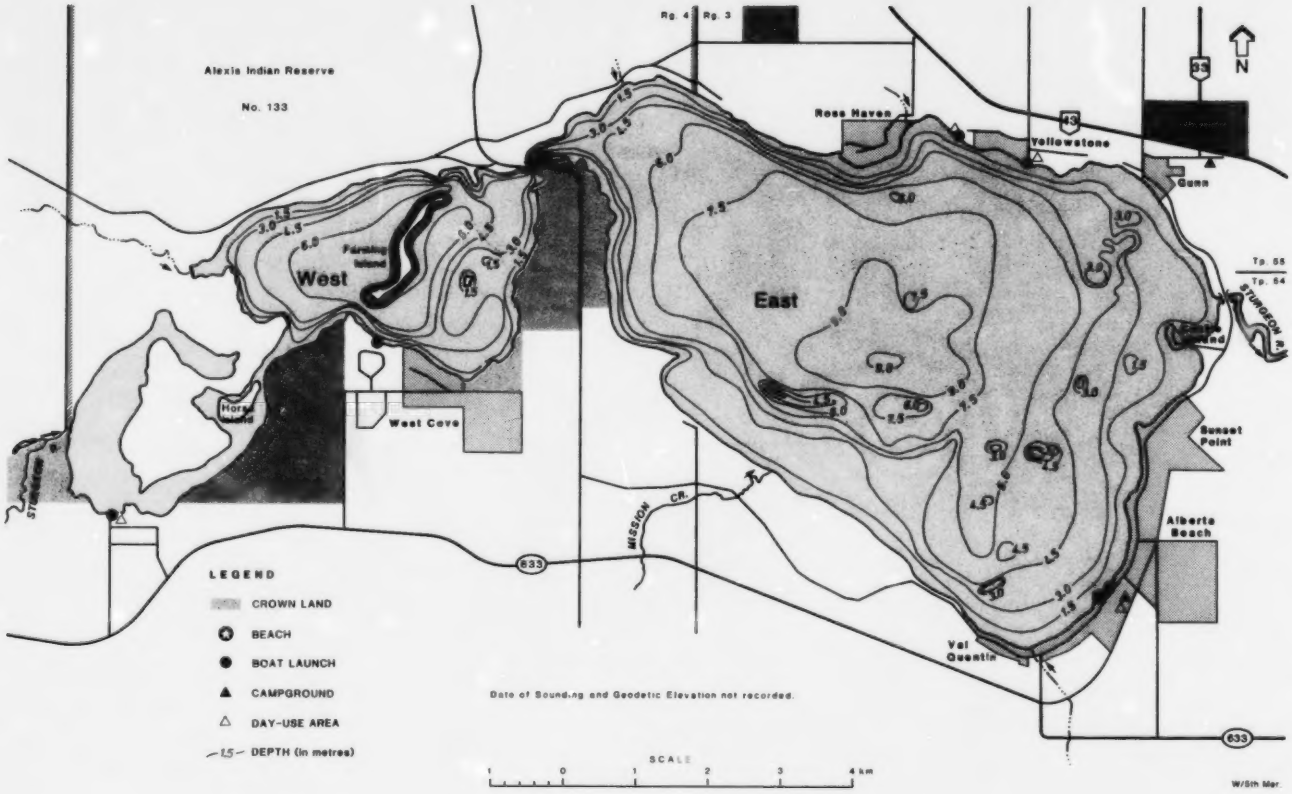
Physical Characteristics

Lac Ste. Anne has two basins that are very different from each other (see the Depth Contour map). The west basin is small and shallow; much of it is less than 3 metres deep. The east basin is much larger and reaches a depth of 9 metres in its center. Water flow between the two basins is restricted where they join at 'the narrows'.

The major inlet to Lac Ste. Anne is the Sturgeon River, which enters the west basin from Lake Isle. A number of smaller streams also drain into Lac Ste. Anne. The Sturgeon River flows out of the lake at the east end and then through Big Lake before joining the North Saskatchewan River.

1. Alberta Culture, Historical Resources, Historic Sites Service
2. Alberta Forestry, Lands and Wildlife, Fish and Wildlife Division

Depth Contours of Lac Ste. Anne

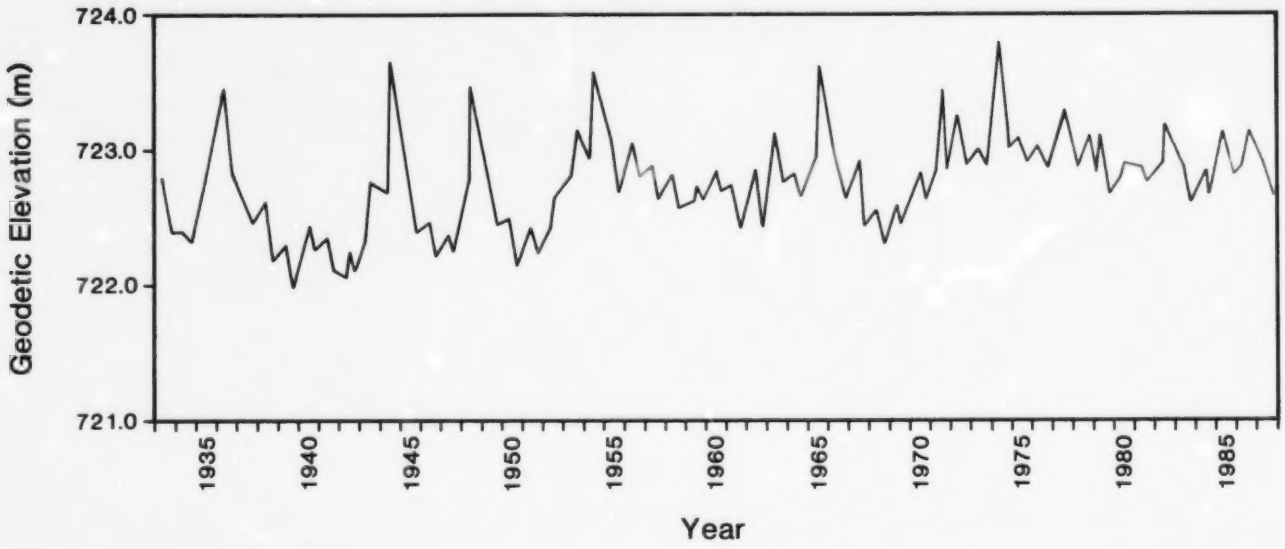


PHYSICAL AND HYDROLOGICAL CHARACTERISTICS		
LAKE AREA	km^2	54.5
DRAINAGE AREA (excluding lake)	km^2	619
DRAINAGE AREA/ LAKE AREA		11.4
VOLUME	m^3	263 x 10^6
MAXIMUM DEPTH	m	9.0
MEAN DEPTH	m	4.8
SHORELINE LENGTH	km	63.6
INFLOW	m^3/yr	51 x 10^6
RESIDENCE TIME	years	18

The Historical Water Level graph shows the variation in water level of Lac Ste. Anne since 1933. A weir was installed on the outlet in 1951 to reduce the incidence of low water levels. It had a moderate effect, but the weir is probably not very functional now. High water levels sometimes cause problems as cottages may flood when the level increases above about 723.3 metres.[3] As the Historical Water Level graph shows, periodic high water levels have been part of the natural history of Lac Ste. Anne for many years.

3. Alberta Environment, Planning Division. 1977. Interim report - Sturgeon river Basin study.

Historical Water Level of Lac Ste. Anne



Nutrient Sources

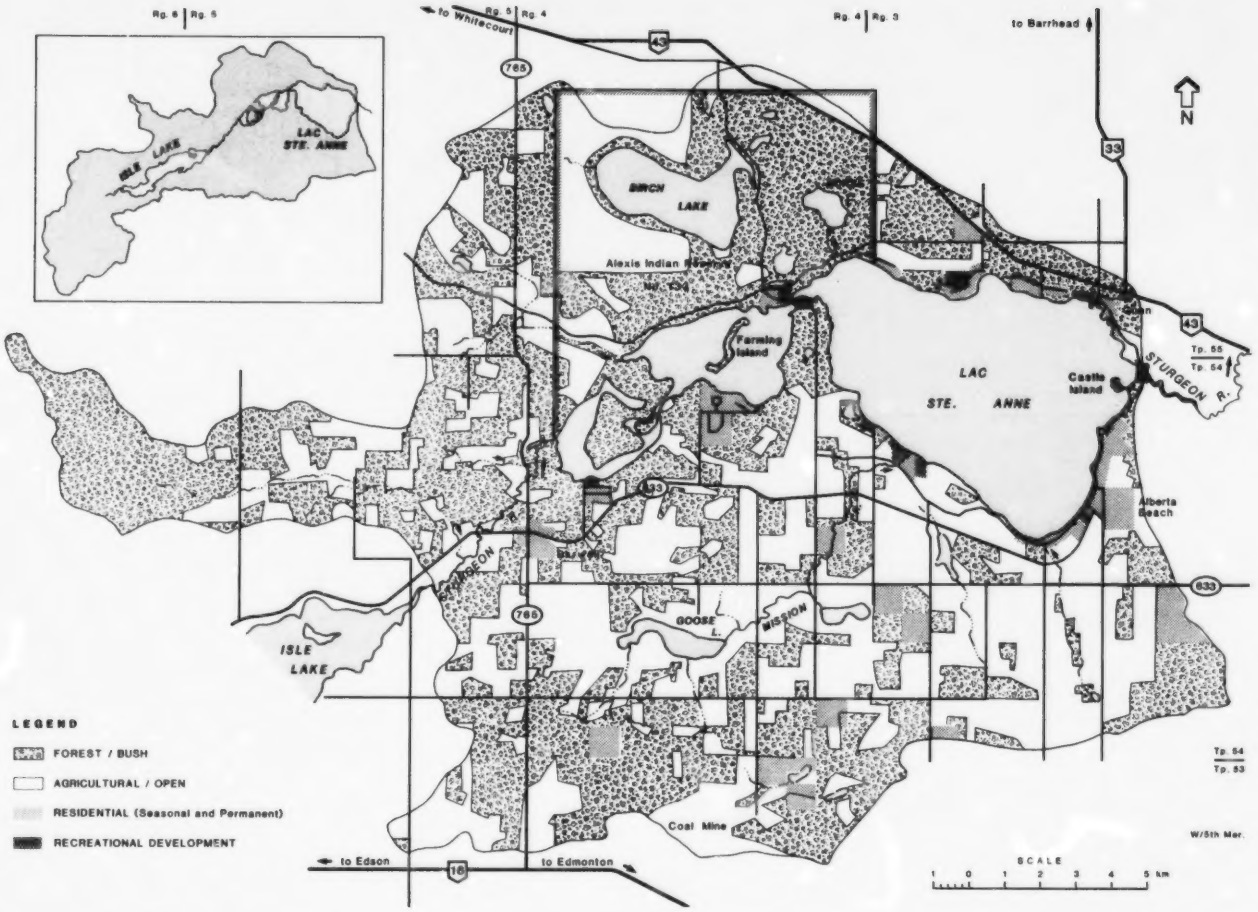
The entire drainage basin of Lac Ste. Anne, as shown on the inset to the Watershed map, is very large. This suggests that the load of nutrients washing into Lac Ste. Anne is tremendous. However, most of the nutrients from the western portion flow into Lake Isle, where they remain 'trapped', effectively reducing the load to Lac Ste. Anne. In the same way, the west basin of Lac Ste. Anne acts as a 'nutrient trap', reducing the load of nutrients to the east basin. As a result, the west basin is more eutrophic (fertile) than the east basin.

Phosphorus is the major determinant of recreational water quality in Alberta lakes. The Theoretical Phosphorus Supply table shows the estimated amounts of phosphorus entering Lac Ste. Anne each year from different sources. The major external source of phosphorus to this lake is cleared and agricultural land. Forested regions and precipitation on the lake surface also add considerable amounts of phosphorus to the water. Sewage produced by residential and recreational developments contributes a small amount of phosphorus to the lake when compared to these other sources. The quantities listed in the table are estimated using rates derived from studies on other Alberta lakes.

A source of phosphorus within the lake is the bottom sediment. Shallow lakes in Alberta like Lac Ste. Anne frequently produce blooms of algae in late summer. These blooms are fueled by phosphorus that is released into the lake water from the bottom sediment during July and August.

SEE "EXPLANATION OF LAKE CHARACTERISTICS" AT END OF BROCHURE FOR CLARIFICATION OF THESE TERMS AND CONCEPTS.

Watershed of Lac Ste. Anne

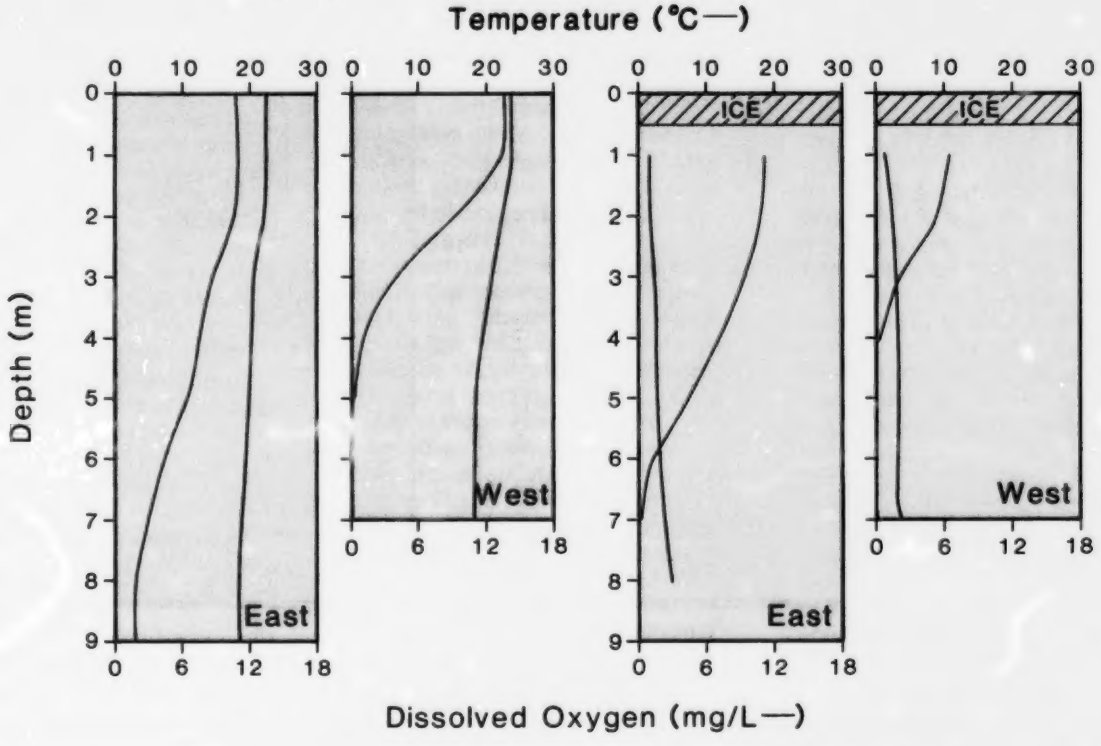


THEORETICAL PHOSPHORUS SUPPLY	kg/year	Percentage
SURFACE RUNOFF:		
Forested/Bush	1768	24.7
Cleared/Agricultural	2740	38.2
Urban/Cottage	553	7.7
PRECIPITATION, DUSTFALL	1190	16.6
FLOW FROM UPSTREAM LAKES	767	10.7
SEWAGE FROM COTTAGES AND CAMPS	153	2.1
TOTAL	7171	100.0
AREAL LOADING, g/m² OF LAKE SURFACE	0.133	

Temperature and Dissolved Oxygen

During hot calm days in summer the surface water in Lac Ste. Anne may warm faster than the deep water. On the Temperature and Dissolved Oxygen graph the summer measurements indicate that the water was about 22°C at the top of the lake and 18°C at the bottom of the lake on 31 July 1984. This very slight amount of layering (see Explanation of Lake Characteristics) may have inhibited complete mixing of the water so that oxygen gradually declined near the bottom. For example, in the east basin, there was only about 2 mg/L of dissolved oxygen in the deepest water, but near the top of the lake there was

Temperature (°C) and Dissolved Oxygen (mg/L) in Lac Ste. Anne



nearly 11 mg/L. Under these conditions fish might not be found in the deepest parts of the lake. In the west basin, oxygen depletion was even more pronounced. On windy days both basins would mix from the surface of the lake to the bottom so that oxygen and temperature would be uniform. Most winters, fish probably move into the east basin to avoid the low oxygen levels that occur in the west end.

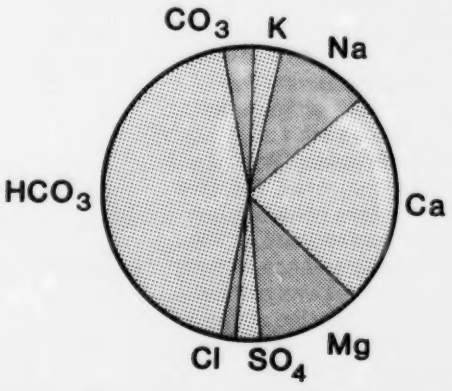
Chemistry

Lac Ste. Anne is a freshwater lake with a fairly low level of salinity (saltiness). The water chemistry is dominated by the ions bicarbonate (HCO_3) and calcium (Ca) as shown in the Ionic Diagram. The composition of ions in the west basin is very similar to that in the east basin.

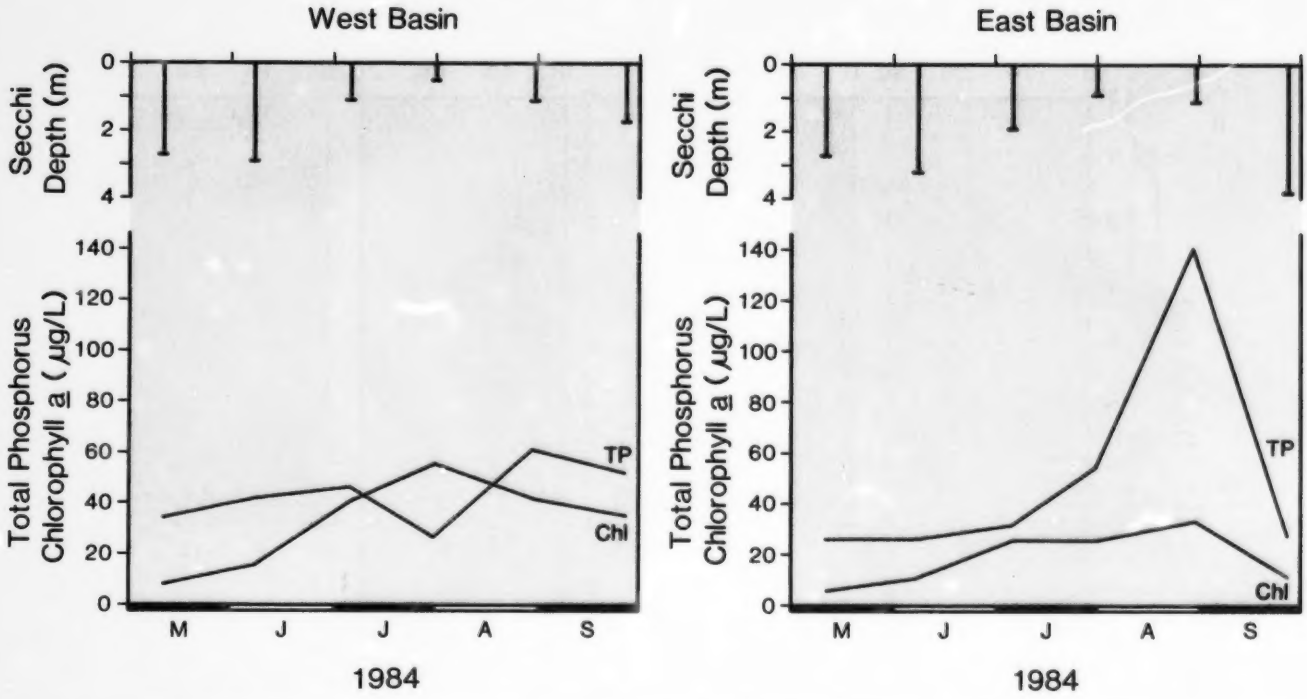
CHEMISTRY Ice-free season averages 1984-1985

		EAST	WEST
TOTAL SALINITY	meq/L	7	6
pH (RANGE)		8.2-8.8	8.0-9.1
ALKALINITY	mg/L	151	142
TOTAL DISSOLVED SOLIDS	mg/L	166	154

IONIC DIAGRAM Relative proportions of ions in Lac Ste. Anne 1984 - 1985



Trophic Status of Lac Ste. Anne



Algae and Trophic Status

The fertility of a lake is evaluated by measuring the amount of algae and nutrients in the water. Lac Ste. Anne is very fertile or EUTROPHIC and therefore it has an abundance of plant life.

The average amount of chlorophyll (algae) in the smaller west basin is considerably higher than that in the east basin. Both are eutrophic, but the east basin generally has better water quality. This may be because of its greater depth and possibly its smaller nutrient load.

In both basins the amount of chlorophyll increased during the summer, as is shown on the Trophic Status graph. As well, the transparency of the water (Secchi Depth) is lowest in summer. This is the time when blooms of blue-green algae may give the water in Lac Ste. Anne a scummy appearance. When these algae reach the peak of their growth and begin to die, the decay process can result in unpleasant odors and occasional fish kills.

In the east basin there was a sharp rise in the phosphorus level of the water in August. This pattern is typical of shallow, eutrophic lakes in Alberta, and results from phosphorus moving up into the water from the bottom sediment. This recycled phosphorus often maintains the algal blooms.

Lac Ste. Anne is a naturally eutrophic lake, like many shallow lakes in Alberta. Sediment cores from the lake bottom suggest that its productivity has been fairly high for the past 5 600 years.[4] The large amount of algae and weed growth is a result of high levels of nutrients entering the lake from the watershed, from precipitation, and from the lake sediment. Agricultural and cottage developments have probably increased the nutrient load into Lac Ste. Anne in recent years although it is difficult to measure these changes.

TROPHIC CHARACTERISTICS Ice-free season averages

		EAST		WEST	
		1984	1985	1984	1985
PHOSPHORUS	µg/L	48	*	44	*
NITROGEN	µg/L	920	894	1186	1129
CHLOROPHYLL	µg/L	17.9	15.0	30.7	31.9
SECCHI TRANSPARENCY	m	2.2	2.5	1.6	2.0

* Data not available

4. Forbes, J.R. and M. Hickman. 1977. The environmental history of Lac Ste. Anne and its basin. Alberta Environment, Pollution Control Division, Water Quality Control Branch.

Explanation of Lake Characteristics

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Drainage Area or the watershed of a lake is the land surface from which a lake receives its water. As rain water or snowmelt gathers in streams, it picks up soil particles, nutrients and other materials and carries them to the lake.

A study of more than 30 Alberta lakes shows that when drainage areas are large compared to lake areas, (i.e. when the **Drainage Area/Lake Area** ratio is large), lakes have more algae (are more eutrophic) (see TROPHIC CHARACTERISTICS).

Mean Depth is the volume of the lake divided by the surface area. Shallow lakes are often more eutrophic than deeper lakes of a similar surface area.

Inflow is the total volume of water entering the lake in a year. It is related to **Residence Time**, which is the time it would take the inflow to completely fill the empty lake basin.

The **Geodetic Elevation** on the water level graph indicates the level or elevation of the lake above mean sea level.

TEMPERATURE

Alberta lakes show two basic annual patterns of temperature distribution through the water.

Deep lakes, or those protected from strong winds, form layers with the coldest water near the bottom in summer. Because this colder water is denser, it resists mixing into the warmer, lighter, upper layer.

For much of the summer, the bottom portion of water is isolated from the top portion. In spring and fall, these lakes usually mix from top to bottom by wind action as the water becomes uniform in temperature and density. In winter, under ice, the warmest water (about 4°C) is on the bottom, because water is most dense at this temperature.

Shallow lakes mix throughout the summer or layer only temporarily. In winter, the temperature pattern of these lakes is similar to that of deep lakes.

DISSOLVED OXYGEN

Oxygen is essential to the life in lakes. Oxygen from the air dissolves readily in water, especially on windy days when waves break up the lake surface. The photosynthesis of small aquatic plants also supplies a large amount of oxygen to the lake water.

Oxygen is consumed by respiration of animals and plants, and by the decomposition of dead organisms by bacteria. A great deal can be learned about the "health" of a lake by studying its patterns and quantity of oxygen.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen throughout the year at all depths. But as a lake becomes more eutrophic, and increasing quantities of plants and animals respire and decay, the balance shifts towards consumption — especially near the lake bottom where dead organisms accumulate.

In deep productive lakes (see TEMPERATURE), the oxygen in the isolated bottom layer may deplete rapidly, forcing fish to move into the upper layer (fish are stressed when oxygen falls below about 3 mg/L). Fish kills occur when decomposing or respiring algal populations use up the oxygen. In summer, this usually happens when an algal bloom "collapses" or dies suddenly.

SALINITY AND TOTAL DISSOLVED SOLIDS

Lake water contains a multitude of dissolved substances. These can be seen by allowing a dish of lake water to evaporate. If the water is filtered to remove living organisms and other particles, and then allowed to evaporate, the residue is called **Total Dissolved Solids**.

The ions* that make up most of this residue can be measured individually, giving a value for **Total Salinity** when added together. The **Ionic Diagram** presents all of the major ions in a lake in proportion to each other.

Salinity is controlled by the types of rock or soil in the watershed and by the amount of evaporation relative to precipitation. Lakes of high salinity, such as many of those found in southeastern Alberta, have fewer species of plants and animals than freshwater lakes; many are too saline to support fish.

* Ions: Chemical form in water of constitutents such as sodium and carbonate.

pH AND ALKALINITY

The **pH** of lake water refers to its concentration of hydrogen ions on a scale that runs from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral - neither acidic nor alkaline.

Most Alberta lakes fall between pH 6 to 9, with the majority on the alkaline side. **Alkalinity** refers to the capacity of water to neutralize an acid, and is a measure of the alkaline materials present in the water.

Alberta lakes that were formed in sedimentary bedrock have a large capacity to neutralize acids entering them, such as from acid rain.

THEORETICAL PHOSPHORUS SUPPLY

Lake scientists know that for most lakes, the amount of algae in the water is related directly to the amount of phosphorus. This is because phosphorus is usually in shortest supply relative to all the nutrients that lake plants need. When it runs out, the algal population can no longer increase. A larger phosphorus supply usually results in more algae.

Based on studies from all over North America, the quantity of phosphorus contributed by a hectare of forest during runoff is remarkably similar no matter where the lake is located. Similarly, agricultural or cleared land overlying sedimentary bedrock contributes fairly similar quantities of phosphorus per hectare in most lake watersheds. This was confirmed for Alberta by measuring quantities of phosphorus supplied by various land uses in several lake watersheds.

In all studies, the phosphorus supply from cleared or agricultural lake was greater than that from forest, averaging 2 to 5 times more.

The **Theoretical Phosphorus Supply** is estimated by multiplying phosphorus supply factors for each type of land use by the area of that land use, and then summing the products.

Similar factors are used for the supply from precipitation. The supply from sewage is estimated based on a percentage of the total amount that could be generated by cottages and camps on the particular lake.

It might be expected that a large phosphorus supply would produce a eutrophic lake. But the size of the lake is also important. If the total phosphorus supply is divided by the surface area of the lake, the resulting **Areal Loading** figure can be compared with other lakes, and can be used as an indication of trophic status.

TROPHIC CHARACTERISTICS

The word "trophic" literally means nourishment.

Mountain lakes usually are "poorly nourished" or **oligotrophic**. Levels of nutrients such as phosphorus and nitrogen are low, plant life is sparse, and the water is clear. Fish production is low.

On the other end of the scale are well-nourished or fertile lakes called **eutrophic**. In these lakes, aquatic plants, including tiny suspended algae, flourish because the water contains abundant nutrients.

Mesotrophic lakes, those intermediate in fertility, often combine the best features of the other two types.

In some lakes, the nutrient supply is so high that plant growth inhibits certain recreational uses of the lake. Lake users may consider such a lake to have poor water quality. One of the purposes in studying lakes is to determine whether fertility is increasing.

There are several ways to measure a lake's fertility or **Trophic Status**.

Phosphorus and **nitrogen** can be measured directly. Phosphorus in lakes of the Boreal Forest/Parkland areas of Alberta ranges between 10 and 200 micrograms per litre* (μg/L) (oligotrophic to highly eutrophic), and nitrogen ranges between 500 and 3500 μg/L.

Transparency of the water declines as a lake becomes more fertile. It is measured with a black and white plate called a **Secchi Disk**, which is lowered through the water on a line marked at metre intervals. The depth at which it can no longer be seen is the **Secchi Transparency**.

The quantity of algae in the water can be determined by measuring its content of **Chlorophyll a**, the green photosynthetic pigment.

* equivalent to parts per billion